THREADED BOLT HAVING MEASUREMENT PLANES FOR USE IN ULTRASONIC LENGTH MEASUREMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Patent Application Serial No. 09/955,522, filed on August 18, 2001, which was a continuation of PCT/NL00/00087, filed on February 11, 2000, which claimed priority to Netherlands application no. 1011591, filed March 18, 1999.

TECHNICAL FIELD OF THE INVENTION

[0002] The invention relates to a threaded bolt provided with measurement planes for use in ultrasonic length measurement. More specifically, after the threaded bolt has been used to form a connection, a measurement is taken to determine the length change of the threaded bolt, and therefore determine the tension within the threaded bolt.

BACKGROUND OF THE INVENTION

[0003] It is known to provide a threaded bolt with measurement planes. Typically, the measurement planes are formed either at a recess or an elevation with respect to the actual end planes of both the head end and the insertion end. The measurement planes are often formed by means of cold deformation and finishing. One such threaded bolt is described in European patent application 0.459.365 which issued May 28, 1991, the contents of which are incorporated herein by reference.

[0004] Another threaded bolt is known from US patent 4.846.001 which issued July 11, 1989, in which the threaded bolt is shown as having a head which has been

provided with a recess including a measurement plane. The measurement plane has been made sufficiently smooth/level by finishing, in order to be used in ultrasonic measuring. The recess is used for accommodating a piezo-electric sensor. In another embodiment the recess is absent and the sensor is placed on top of the end plane at the head.

[0005] Frequently, existing threaded bolts exhibit several radial planes at one or both ends, situated at various axial distances measured along the center line of the threaded bolt, which can adversely affect the ability to achieve accurate measurement results.

SUMMARY OF THE INVENTION

[0006] It is an object of the invention to reduce the number of radial planes exhibited by the threaded bolt, thereby improving the accuracy with which ultrasonic length measurements on the bolt can be performed.

[0007] One embodiment of the invention provides a threaded bolt having a proximal head end and a distal insertion end, wherein the proximal head end and the distal insertion end have been provided with a single, exposed radial measurement plane for use in ultrasonic length measurement in order to determine the tension in the threaded bolt after it has been used in a connection. The measurement plane at the distal insertion end is formed by the flat bottom of a recess at the distal insertion end, wherein the recess is bounded by a circumferential wall. The circumferential wall transitions into the flank of the distal insertion end via a buckle or curve. Therefore, multiple radial planes at the insertion end other than the measurement plane are prevented. Therefore, the ultrasonic length measurement is related only to the measurement plane at that location and double signals are prevented. The measurement plane is protected from pollution and damage by the recess.

[0008] Another embodiment of the invention provides a threaded bolt having a proximal head end and a distal insertion end, wherein the proximal head end and the distal insertion end have been provided with a single, exposed radial measurement plane for use in ultrasonic length measurement in order to determine the tension in the threaded bolt after it has been used in a connection. The measurement plane at the distal insertion end is formed by the flat bottom of a recess at the distal insertion end, wherein the recess is bounded by a circumferential wall and the outermost distal end of the threaded bolt is formed by a circular line.

[0009] In preferred embodiments, the transition from the circumferential wall of the recess into the flank of the distal insertion end may run according to a convex course, but preferably has a sharp buckle shape, thereby ruling out the occurrence of murmur while taking measurements as much as possible.

[0010] Preferably the circumferential wall of the recess forms a conical surface which is oblique with respect to the bolt center line, the angle of which is maximally 75° with respect to the bolt center line, preferably also more than 45°.

[0011] Preferably the flank in the distal end portion, which is contiguous to the circumferential wall of the recess, forms a flank conical surface oblique with respect to the bolt center line, the angle of which is maximally 45° with respect to the bolt center line. Preferably the flank conical surface at the proximal side changes into the cylindrical plane via a flank conical surface which is less oblique with respect to the bolt center line, for instance at 25-35°, which cylindrical plane may or may not be contiguously provided with the thread. Alternatively, the distal end of the bolt provided with the aforementioned recess is truncated at the flank.

[0012] Preferably the recess has been formed by means of an upsetting treatment of the insertion end. As a result of the upsetting treatment, the distal end of the bolt can

be provided with its final form in one step. Alternatively, apart from the upsetting treatment for forming the recess, the oblique flank can be obtained by means of a machining treatment.

[0013] It is a further object of the invention to provide a threaded bolt which can easily be manufactured and is able to provide reliable measurement results.

[0014] To that end, a preferred embodiment of the invention provides a threaded bolt having a proximal head end and a distal insertion end, the proximal head end and the distal insertion end being provided with measurement planes for use in ultrasonic length measurement in order to determine the tension in the threaded bolt after it has been used in a connection. The measurement plane at the insertion end forms the complete end plane and has been arranged on the insertion end without a final processing operation.

[0015] In preferred embodiments, the measurement plane has been arranged at the distal insertion end by means of an upsetting treatment. The upsetting treatment can advantageously be performed during a heading treatment performed in a bolt machine, also known as "bolt maker". In such a bolt machine, the upsetting of the head takes place in one operation. During the upsetting treatment, the measurement planes can be realised at both ends. Therefore, the exact axial distance between both measurement planes can be determined.

[0016] Alternatively, the upsetting operation for making the measurement planes may take place during the subsequent shank reduction.

[0017] By way of a further alternative, instead of by means of the upsetting treatment, the measurement plane at the insertion end can be made in the same bolt machine, but in a following station, where the point is made. This then takes place by means of a machining treatment.

[0018] The invention furthermore provides a method for manufacturing a threaded bolt according to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The invention will now be elucidated on the basis of the examples shown in the attached drawings, in which:

[0020] Figure 1 shows a threaded bolt according to the invention, having a recessed measurement plane at the distal end;

[0021] Figure 1A shows a detail of the distal end of the threaded bolt of figure 1;

[0022] Figures 2A and 2B show two exemplary embodiments of another threaded bolt according to the invention.

[0023] Figure 3A shows a view of a bolt machine for manufacturing a threaded bolt according to the invention;

[0024] Figure 3B shows consecutive stations within the bolt machine of figure 3A; and

[0025] Figure 4 shows a possible embodiment of the point making machine accommodated in the bolt machine according to figure 3B.

DETAILED DESCRIPTION

[0026] The threaded bolt 1 shown in the figures 1 and 1A comprises a shank 2 having a widened head 3 with flange 4, in which a thread 5 has been arranged on the shank 2. The distal end 6 of the shank 2, and thus the bolt 1, is shown enlarged in figure 1A. As shown in figure 1A, a recess 7 has been made in the distal end 6, the recess being axially bounded by a flat bottom 8 which extends perpendicular to the center line X of the bolt 1. The recess is radially bounded by an inclined circumferential plane 9

running concentrically about the center line X, the plane 9 is at angle *a* of 45°-75° with respect to the center line X. Via a sharp, line-shaped transition 10, which in end view forms a circular line, the distal end 6 changes radially to the outside into an inclined circumferential plane 11 which is also concentric with respect to the center line X. Inclined circumferential plane 11 is at an angle β with respect to the center line X, β maximally being 45°. It can be seen that the inclined circumferential plane 11, via a buckle, changes into a comparable inclined circumferential plane 12. However, inclined circumferential plane 12 is at an angle γ with respect to the center line X, which is different from the angle β and which here is 25 to 35°.

[0027] At the head 3 a flat plane 14 has also been provided on the end plane 13, which just like plane 8 is perpendicular to the center line X is suitable to serve as a measurement plane in ultrasonic measurements. The plane parallelism here amounts to a least 0.05 mm.

[0028] The recess 7 and the measurement plane 8 can be formed in a simple manner by upsetting the distal end 6 of the bolt (preferably made of steel) in a pointing machine. In the same upsetting treatment the circumferential planes 11 and 12 can be made. Alternatively, said planes 11 and 12 can be made by means of a machining treatment, as is discussed hereinafter in relation to figure 4.

[0029] During measuring, the sensor will be placed against the measurement plane 14, possibly with the help of a very thin layer of contact adhesive. With the help of ultrasonic measurement, the distance S, measured in a direction parallel to the center line X between the planes 8 and 14 (against which the sensor has been placed), can be exactly measured and determined. With that distance, the tension in the bolt can be determined. The accuracy of the ultrasonic measurement is improved as a result of

only one radially oriented plane 8 being present in the distal end 6, therefore preventing multiple measurement signals.

[0030] By way of example, with a diameter of the circular line 10 of approximately 12 mm, the diameter of the plane 8 may be 4 mm.

[0031] Just like the measurement planes of the threaded bolt to be discussed below and shown in the figures 2A and 2B, the measurement planes 8 and 14 may be formed without final processing operations, meaning that for plane 8 the upsetting treatment can be the last treatment of the plane.

[0032] In figure 2A, comparable bolt parts as compared to the bolt in figures 1 and 1A are shown with comparable reference numbers, increased by 100. Thus, the bolt 101 is provided with a distal measurement plane 108 and with a proximal measurement plane 114 which forms the bottom of a recess 115 in the proximal end plane 113 of the bolt 101. A sensor may be placed in the recess 115. In this case, the distance S between the measurement planes 108 and 114 is exactly known beforehand. The recess 115 and the measurement plane 114 have been formed during flat pre-upsetting (also see figure 3B), without final processing treatments (such as grinding) of the measurement plane. The measurement plane 108 has been formed here during upsetting, also without final processing treatments of the plane.

[0033] In figure 2B an alternative threaded bolt 201 has been shown, in which the same parts have the same reference numbers again, increased by 100 over those in figure 2A. In this case the measurement planes 208 and 214 have been formed at both the proximal end and at the distal end of the bolt 201. Just like the measure plane 108, the measurement plane 208 extends over approximately the entire diameter of the distal end, or insertion end.

[0034] In figure 3A, a bolt machine 320 is shown with which the bolts according to the figures 1, 2A, 2B, and alternative embodiments can be made. Metal wire 321 is supplied from a roll 322, passes through the supply end 323 of the bolt machine 320 and is processed into threaded bolts. The threaded bolts are provided with measurement planes according to the invention and are discharged at the discharge end 324 where they are collected in a tray 325.

[0035] The bolt machine 320 includes a thread cutter for cutting a workpiece for the bolt (see figure 3B), a station 402 for pre-upsetting (after which the workpiece 401a is obtained), a station 403 for heading (after which a workpiece 401b is obtained), a station 404 for reducing the shank (after which a workpiece 401c is obtained), and a station 405 for trimming (after which a workpiece 401d is obtained). The workpieces 401d are subsequently subjected to a point-making treatment in a pointing machine accommodated in the same bolt machine 320, and after that to a thread rolling treatment, also in the same bolt machine 320.

[0036] As stated, the measurement planes in the bolts according to the invention can be arranged by cold deformation during heading, in station 403, either by integrally forming a recess in the head or not. During this upsetting of the head use is made of an especially formed stamp in station 403. For making the measurement plane at the distal or insertion end a push-out pin 426 or 427 especially formed for that purpose can be used for deforming the distal end in the wanted manner by upsetting in station 402 or 403.

[0037] Thus, without particular further provisions, a threaded bolt can be formed having measurement planes which are suitable for ultrasonic length measurements.

[0038] The pointing machine 530 of figure 4, accommodated in the bolt machine 320, can alternatively be used for making the measurement plane at the distal end which is

formed by the end plane of the distal end. As can be seen, two cutter plates 531 and 532 have been arranged which are hingeable and can be adjusted in angular position. The cutter plate 531 is positioned inclined and the cutter plate 532 horizontally to cut the measurement plane. Here again, the exact distance between both the measurement/end planes is known. Both cutter plates are rotated about the insertion end, whereas the bolt is held against rotation.